NOTE ON THE INNOMINATE BONE AS A FACTOR IN THE DETERMINATION OF SEX: WITH SPECIAL REFERENCE TO THE SULCUS PRÆAURICULARIS.

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THE determination of sex is a matter of first importance in all anthropological work, if reliable records are to be made or accurate deductions drawn from the material employed.

In many instances this presents no difficulty, but in others the circumstances may be such that only the bones of the skeleton are available for the purpose, and it is in these cases that every indication is of value which may lead to the correct identification of the sex of the individual.

The sexual characteristics are, as a rule, most marked in the pelvis, and the latter has therefore always held the first place as a means of deciding the question in favour of male or female; but where one or more of these bones is absent or broken, or in the not uncommon occurrence of a pelvis of one sex simulating that of the other, it becomes necessary to rely upon such information as may be gathered from single bones or parts of bones, as the case may be.

The object of this paper is to show that this may be accomplished by attention to certain points in the isolated innominate bone, not usually emphasised in anatomical works, which, as a rule, confine their attention to a comparison between the complete male and female pelvis. The accompanying photographs serve to bring out the fact already mentioned, that even the complete pelvis is at times not obviously male or female, at least in the pubic region, where the most marked differences are usually expected; indeed, in these cases, this part is often most unreliable, and if the observer were to judge by it alone, his diagnosis of sex would be frequently erroneous. If this is true for the complete pelvis, it will be obvious how much more deceptive it must be when only one innominate bone is present.

In pursuing this question, 406 bones were examined, representing 235 individuals; 100 of these were sexed, by the method to be described, as those of males, and the remainder as females. They were represented either by complete pelves or separate innominate bones. In cases where only one innominate bone was available, it was as often as possible conjoined with the

sacrum, not so much for any sexual characteristics which might be exhibited by the latter bone, as for certain well-marked peculiarities which the union of the two bones made clear.

Many of the complete pelves used had been previously articulated very carefully by Dr Hildebrandt of Cairo. These which represent the Predynastic Egyptian period are mostly very fragile, and it is necessary to employ glue to make them adhere, as any other method might damage them irreparably. But in the more recent bones, the writer found an ordinary elastic band very effective in holding the three bones together, and it has the additional advantage of allowing the separate constituents of the pelvis to be taken apart for individual examination. No attempt was made to restore the original form of the pelves by the introduction of any material between the articulating surfaces, as was done by Sir William Turner (1) in his report on the *Challenger* pelves, for the reason that this investigation had for its object not so much a comparison and measurement of pelves as a whole, but rather the special examination and comparison of the isolated male and female innominate bone.

Most of the points referred to hereafter will be familiar to all anatomists, and have been recognised as distinctive of sex; one at least, however, the writer believes to be new, and others are so applied as to be of more practical value than has hitherto been the case.

As the intention of this paper is to lay stress upon sexual characteristics other than those associated with the pubic region, attention will in the first place be directed to the ilium, as this portion of the innominate bone has very distinctive features in the two sexes, and further, it is often the only part of the bone which is intact.

It would appear that though numbers of observers have made comparative measurements of the male and female pelvis, few have traced the recorded results to the anatomical differences between the bones of the two sexes; for although such pelvic measurements are valuable in obstetrics, they are of no practical use in distinguishing a male from a female innominate bone.

Professor Arthur Thomson (2), however, in a paper on "Sexual Differences of the Fœtal Pelvis," has remarked upon certain very important points which are observable even in the antenatal bones, and still more so in the adult condition. Two of these features deserve special attention, and will be considered together.

The first of these two points has reference to the curve of the iliac crest, which Thomson notes "reaches a higher level and is more pronounced in the male than in the female, as happens also in the adult forms." This is a character which may be easily recognised if a series of male and female

bones be compared. The male iliac crest describes a much smaller circle, and the posterior part of the bone descends steeply to its termination. The female bone, on the other hand, appears to be elongated in an antero-posterior direction, and does not descend posteriorly as in the case of the male. This difference in shape results in a marked change in the size of the great sacro-sciatic notch in the two sexes, and this second point is also shown in Professor Thomson's fœtal pelves. This author says that "the form of the notch depends on the relation of the sacrum to the innominate bone, its shape being modified by the degree of curvature of the sacrum";

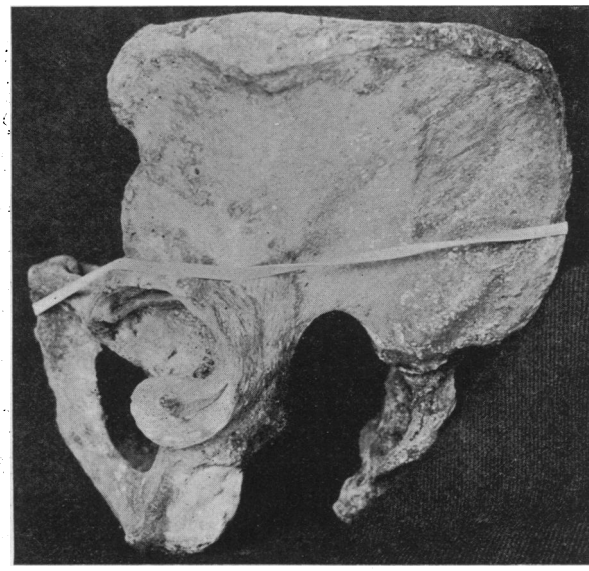

FIG. 1.—Male.

but he adds that "this reacts on the shape of the ilium." This is an important admission, as the great difference between the appearance of the notch in the two sexes is a remarkable feature of the majority of isolated innominate bones, and the presence of the sacrum is not necessary to exhibit it. When, however, the latter bone is articulated with the ilium, the distinctive shape of the notch in the two sexes is accentuated.

If a reference be made to fig. 1, the contrast between the notch in these two pelves will be seen. It is obvious from this that the immense width of the female notch is due entirely to the shape of the ilium, which carries the sacrum back with it. It should be noticed that the posterior boundary of the notch is formed in the female case by the sacrum alone, whereas in

the male pelvis figured this boundary is partly constituted by the ilium, which curves more steeply downwards, as already pointed out. From what has been said, it will be clear that the female ilium is characterised by a very definite form, and one which, as Thomson has shown, is already present in the fœtus. A further fact in support of this is also brought out by this writer in the excellent photographs accompanying his paper. The greater inclination of the female pelvis as compared with the male is shown to be due, not entirely to a subsequent change in the spinal curve,

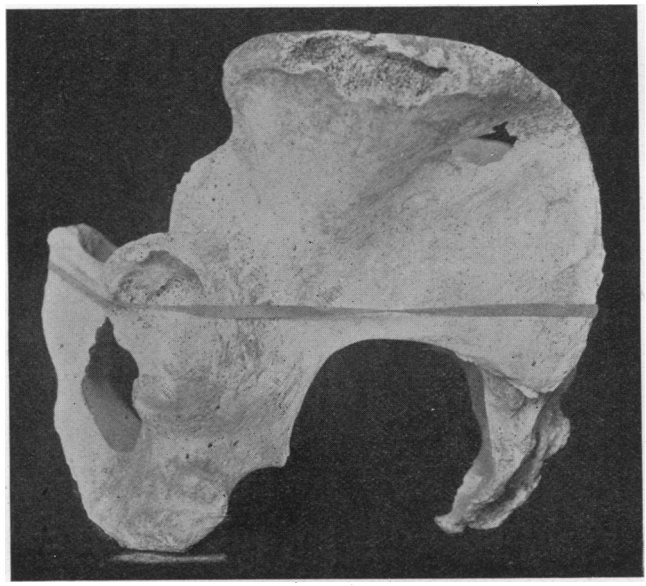

FIG. 1.—Female.

seeing that this increased inclination is present in the fœtus from an early date, but rather to a different placing of the sacrum in relation to the ilium, a condition of affairs necessitated by the peculiar shape of the female innominate bone.

This peculiar shape, which from its presence in the fœtus Thomson regards as "being due to an inherent difference in the forms of the bones and cartilages," may possibly have a further significance; for if the pelves of various lower mammals be examined, it will be noticed that generally they agree in the width and shallowness of the sciatic notch. Now in these animals the position of the pelvis is such that during parturition a large subpubic angle is of little value, the fœtus passing directly backwards

beneath the tail, and not forwards along the pelvic floor, as in the final stage of the human act of parturition. But in this latter case also, great width of the sciatic notches, with consequent backward displacement of the sacrum, will provide greater space for the fœtal head at that period of labour where the perineal floor is bulged outwards by its advance, and further, will to some extent obviate the necessity for a large subpubic angle.

In fig. 2, which is a photograph of the same female pelvis shown in fig. 1, but seen instead from the front, it will be noticed that the subpubic angle is considerably smaller than that of the typical female shown in fig. 3.

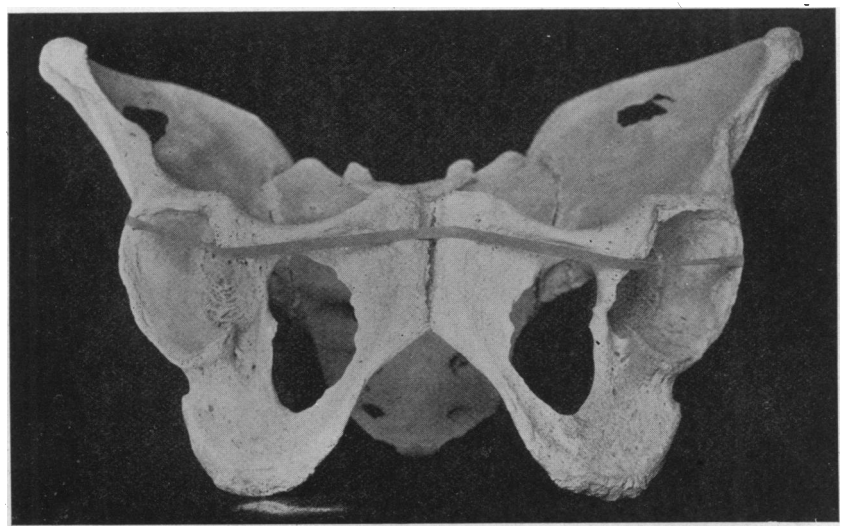

Fig. 2.—Female.

At the same time this smallness of the angle is more than compensated for by the widely opened sciatic notches of this pelvis. In other words, the female pelvis exhibits the persistence of an anatomical character common in many of the lower mammals, and it may be argued *à priori* that greater ease in parturition should accompany such a condition in the human subject.

Another feature of considerable significance in determining the sex of a given bone may be found in the groove or fossa first described by Zaaijer (3) in 1866, who observed it in 23 out of 26 female Javanese pelves. The groove in question is situated on the ilium immediately in front of the lower part of the auricular articular surface, and Zaaijer called it the sulcus præauricularis. He considered it to be caused by the attachment of the anterior sacro-iliac ligaments to the ilium in that position. Numerous

authors since Zaaijer's first description have commented on his sulcus and have given various accounts of its causation. These are well summed up in a paper by Dr Pipin Löhr (4) in the *Anatomischer Anzeiger* of 11th June 1894, Band ix. p. 521, entitled "Ueber den sulcus praeauricularis des Darmbeins und ähnliche Furchen anderen Knochen." This writer gives a complete account of Zaaijer's work on the subject, as well as a review of the ideas of subsequent authors as to the significance of the sulcus. He concurs with Zaaijer as to its being the seat of attachment of the anterior sacro-iliac ligaments, and ends by giving the results of his own observations on a large number of pelves as well as isolated bones.

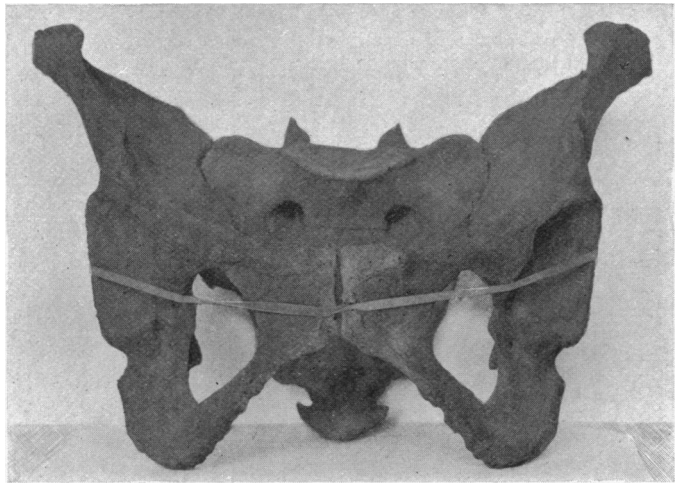

FIG. 3.—Female.

In spite, however, of the striking fact that Zaaijer himself who first noticed this sulcus, observed it no less than 23 times in 26 female bones, and that Dr Löhr, in his special study of the groove, actually found it present 41 times out of 59 female pelves, as against 19 out of 34 male, neither of them has remarked upon it as being at least more common in the female subject.

Dr Löhr did not feel himself competent to give a definite diagnosis of sex in the seventy isolated innominate bones which he also examined. Had he been able to do so he would probably have been led to notice not only the extraordinary frequency of this sulcus in the female, but also its much greater definiteness and size in this sex, as compared with the male. However this may be, the fact remains that the sulcus præauricularis of Zaaijer

—called by Spalteholz sulcus paraglenoidalis—is far more common and also better marked in the female than in the male.

Poirier (5) remarks that the sulcus is almost constant, but though this is true as regards the presence of at least some indication of a groove on the majority of bones, the contrast between that seen in most female bones and the corresponding sulcus in the male is generally so pronounced as to

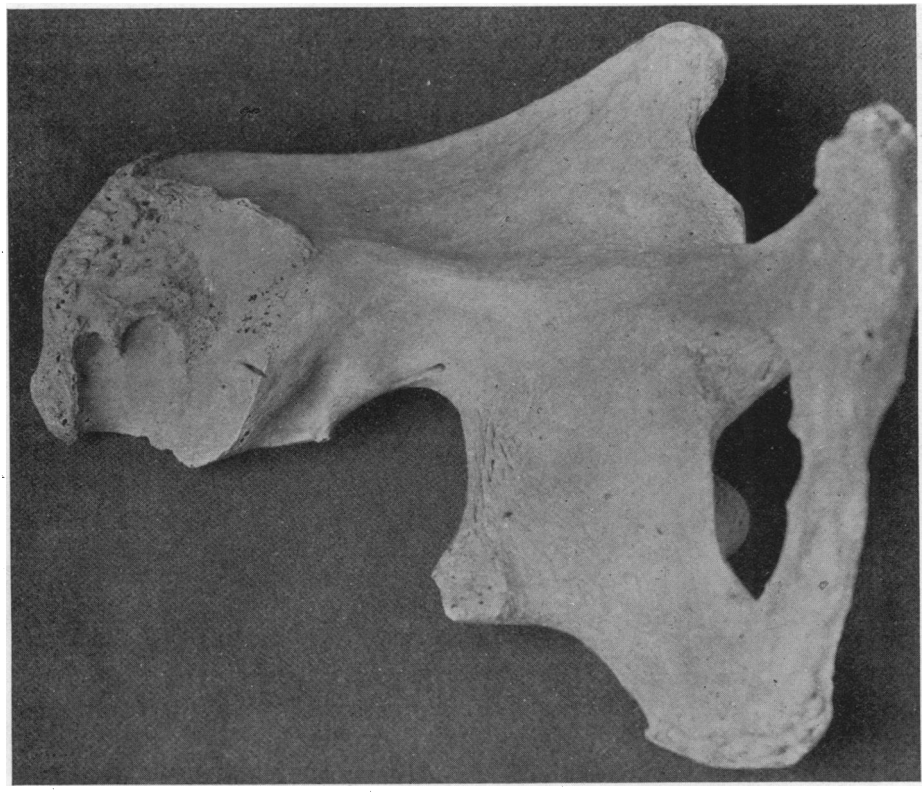

FIG. 4.

leave no doubt in the mind as to the sex to which the bone in question belongs. In most female innominate bones (see fig. 4) the sulcus is broad and deep, frequently with sharp overhanging edges, and often pitted, the floor of the groove being of unequal depth. It does not, as a rule, extend much above a line corresponding to the lower half of the auricular surface, and is better marked below than above. It may, as pointed out by Dr Löhr, extend round the lower margin of the auricular surface to join a

similar depression behind it. In female bones it averages 8 mm. in its widest part and 29·5 mm. in length. The greatest breadth met with was 13·5 mm. (see fig. 5), and the greatest length 35 mm. In considering this groove only that portion lying below the ileo-pectineal line is taken into account, as this is the part which shows sexual variation. The ilium above the line mentioned may be slightly grooved for ligaments, but there is nothing characteristic about it.

In the case of the male bone a very different state of affairs presents itself. Only rarely—three times in 167 bones—did the sulcus at all resemble

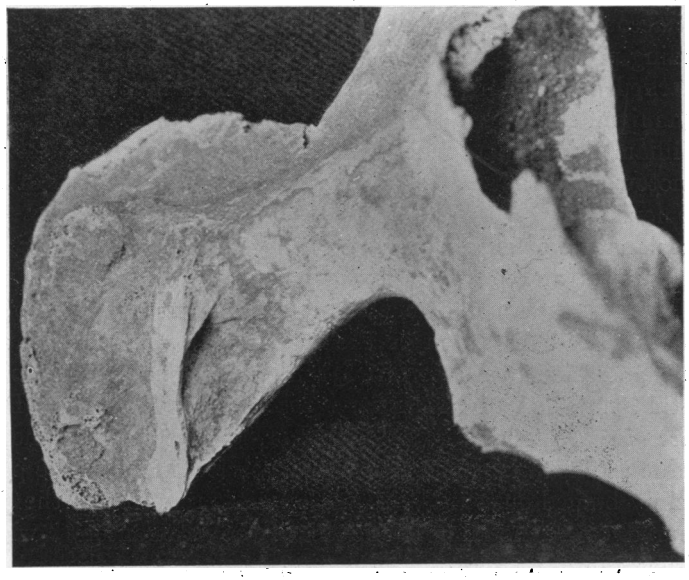

Fig. 5.

the typical female groove. In the largest of these three it measured 5 mm. in width and 22 mm. in length, but it was very shallow and lacked the well-marked edges of the female sulcus. It is usually either long and very narrow and lies close to the margin of the auricular surface, or it is a slightly roughened area extending outwards to a tubercle which by its elevation above the surrounding surface gives the appearance of a shallow depression between itself and the auricular margin. It may be said at once that both Zaaijer and Löhr are undoubtedly right in stating that this sulcus is occupied by the anterior sacro-iliac ligaments. In the recent pelvis, after removal of all muscles, blood-vessels, etc., there is no sign of this groove. But, if the anterior sacro-iliac ligaments be removed, it is easily

seen in the female subject. A still better method is to saw across the sacro-iliac joint horizontally, when a section of the sulcus will be seen occupied by a mass of fibres, amongst which are many longitudinally directed. These are continuous with the inferior sacro-iliac ligaments which run up to this point from the side of the sacrum under cover of the great sciatic band (lig. sacro-tuberosum).

Poirier concludes, after examining 100 iliac bones, that while the edges of the groove give attachment to ligaments, the bottom of the sulcus is occupied by an arteriole and some large veins. The writer has failed to discover any vessels in such a position, but even if they were present, it would not account for a deep groove in nearly every female, while in the corresponding position in the male there is either no sulcus or only a very faintly marked depression with some degree of roughness for the attachment of the ligaments.

Sir William Turner (1) found the sulcus present in a variety of races, but it is noteworthy that it was most marked in the pelves of Sandwich Island women.

The explanation of such a remarkable sexual character must be sought in the anatomical and physiological differences of the male and female pelvis. Not only is the female pelvis more inclined to the horizon, thus causing a different distribution of the body weight, but the joints between the sacrum and iliac bones permit far more movement in this sex, thus allowing that nutation of the sacrum described by Matthews Duncan (6) (*Researches in Obstetrics*, p. 147). For, during the second stage of labour, while the head is passing over the pelvic floor, and the perineum is being forcibly bulged outwards, greater space is required at the outlet, and this is secured by a "nodding forwards of the promontory" which, while it diminishes the diameter of the conjugate, increases the outlet "about twice as much."

In the pubic region the best guide to sex in the isolated bone is the body. This is, as frequently pointed out, shallower in the female, but it is likewise very much broader, added to which, the descending ramus, instead of appearing as a continuation of the whole of the lower border of the body, as in the male, seems to come principally from the outer part of that border, leaving therefore a portion of the body free, which when joined by the fibro-cartilage to the opposite bone produces the characteristic Norman arch of the female pelvis. It has, however, been already pointed out that this region is not always to be relied upon, and this statement has been recently confirmed by Dr Wood Jones who, in the course of his work in Nubia, has encountered pelves which, if judged from the pubis alone, would have been diagnosed as those of males.

At the meeting of the Anatomical Society held in Edinburgh in July 1907, the writer referred, in a paper on "Prehistoric Egyptian Femora," to the size of the head as an indication of sex. He was not at that time aware of Dorsey's (7) work published in the *Boston Medical and Surgical Journal* of 22nd July 1897, in which that observer showed that sex might be determined with considerable accuracy from measurements of the diameter of the femoral head. What is true for the head of the femur is also true for the socket in which it rests. The size of the acetabular cavity is of the greatest assistance in doubtful cases should other indications be unavailable. The average diameter of the acetabulum in fifty males, measured from the point where the anterior inferior spine touches the margin of the cavity to a point on the opposite margin corresponding to a line continued upwards along the outer margin of the ischial tuberosity, was 52 mm. The highest measurement recorded in this sex was 57·5 mm. and the lowest 45. In the female, however, from the same number of individuals the average was only 46·8 mm., the highest being 52 and the lowest 43 mm. The former number was only recorded once.

It should be noted that the size of the acetabulum in the two sexes is not merely a question of a proportionate difference in the size of the whole bone, for quite small male bones may show a comparatively large acetabulum, while contrariwise a large female bone will carry but a small femoral socket.

Finally, the position of the acetabulum in the two sexes is different. In the female it looks much more distinctly forwards than in the male, in whom it is usually directed outwards. The writer has drawn attention elsewhere to the effect of this on the female femur, which has its upper end twisted forwards in correspondence with the alteration in the direction of the acetabulum. This, however, is not a point which is of much avail in sexing an isolated bone, but it may be noted that it appears very distinctly in the series of fœtal pelves figured in Professor Thomson's paper (Plate xv.), and is evidently, therefore, an inherent characteristic.

In calling attention to the above points of difference in the bones of the two sexes, the writer has purposely avoided giving measurements, except for the acetabulum. The features referred to can be recognised at a glance, and are therefore of value, particularly in field-work, where large numbers of bones have to be dealt with, or where bones are either already badly broken, or are so fragile that articulation and detailed measurements are impossible. Further, all the characters may be observed on the isolated bone, so that the loss of one of the pair does not invalidate the opinion expressed as to the sex of the individual.

In conclusion, it may be said that the method above described has

been tested during the past winter in Nubia by Professor Elliot Smith and Dr Wood Jones, who have had an immense number of bodies to deal with, many of which had still the soft parts in position and could thus be sexed without any reference to the bones. In these cases, therefore, where the sex was certain, the accuracy or otherwise of the method could be easily ascertained, and it was found, in the large majority of instances, to be perfectly satisfactory.

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